Amendments to the Drawings

Please relabel FIG. 2 as prior art.

Please renumber FIG. 6 on sheet 5 as FIG. 5.

The substitute drawings submitted at this time incorporate these changes.

Remarks

Claims 1, 2, 4 – 9, and 12-23 remain in the application.

The examiner has objected to the drawings. Figure 2 should be relabeled as prior art. Figure 6 on sheet 5 should be relabeled as FIG. 5. These changes have been made.

The examiner has rejected claims 11 and 16 under 35 U.S.C. 112, first paragraph for lack of support in the written specification. Although Applicants believe that the fabrication process described at [0119] of US 2006/02614350 adequately supports the uniformity of claim 1, this claim has been canceled since it is rendered superfluous by the larger thickness now recited in claim 1. The examiner states the recitation in claim 16 of the absence of a quantum well and associated barrier lacks support for the barrier since the original specification does not discuss a barrier, as is required for a quantum well. The examiner's statement contradicts itself. The specification does not discuss a quantum well in view of the fact that the described structures lack a quantum well. As is well known in the art, a semiconductor quantum well requires a thickness much less than the 100nm layers typical of the described embodiment. Further, the ordinary mechanic would understand the discussion at [0057] of US 2006/02614350 describes how the inventive device would not work properly if the interelectrode distance (that, the thickness of the ambipolar layer) is 10nm or less, which is the thickness of the quantum well layer described by Kawazu at col. 1, lines 32-33. Similarly, the discussion at [0114] and [0115] contrasts the claimed structure from the conventional *pin* structure, which includes a confinement layer or well having "a thickness in the range of several nm to several tens of nm to spatially confine the carriers to the i-layer." This corresponds to a quantum well as that term is used by the sole reference Kawazu and is well known in the art. Accordingly, the exclusion of a quantum well structure is inherent in the filed application, as is apparent to the ordinary mechanic. Further, since the revised claims require a minimum thickness of 100nm, the absence of a quantum well is inherent in the claimed layer.

The examiner has rejected claims 1-2, 4-9, and 11-18 under 35 U.S.C. 112, second

paragraph for indefiniteness.

The examiner states that "the light-emitting layer" in line 4 of claim 1 lacks support. This rejection seems unnecessary, but claim 1 has been amended to provide complete correspondence between the terms.

The examiner expresses confusion in claim 13 about which limitation the phrase "consisting of" refers to. Commas have been carefully used in this claim to avoid confusion. However, to further clarify claim 13, numerical designations of the various limitations to the light-emitting layer have been added.

The examiner professes confusion in claim 13 between the ambipolar semiconductor material of line 4 and the first ambipolar semiconductor material of lines 7-8. The examiner misreads the claim. The first instance is "an ambipolar **semiconducting** material" while the second instance is "a first ambipolar **semiconductor** material". However, to remove possible confusion, ambipolar has been removed from the second instance, which now refers only to composition.

In claim 17, the examiner states that "essentially" is not defined in the claim and the specification does not provide a standard for ascertaining the requisite degree. The examiner is attempting to require a degree of specificity not required by the code, regulations or judicial finding. As is well held over many years, "consisting essentially" is to be interpreted as being "open to unlisted ingredients that do not materially affect the basic and novel properties of the invention." *PPG Industries v. Guardian Industries Corp.*, 48 USPQ 2d 1351, 1353 (CAFC, 1998). Further, the specification adequately teaches at page 25, line 23 to page 26, line 10 and page 29, lines 6-9 the characteristics of the desired ambipolar material, which differ significantly from the intrinsic layers of the prior art *p-i-n* devices and the quantum wells of the references applied to date, thus ascertaining the requisite degree of non-essential elements allowed by "consisting essentially of". Applicants have used the phrase "essentially consisting" to mean that the material is inorganic even though it may include dopants possibly including carbon.

In claim 18, the examiner states that the conduction band energy is not defined since no reference energy level is defined. The examiner does not completely read the claim which

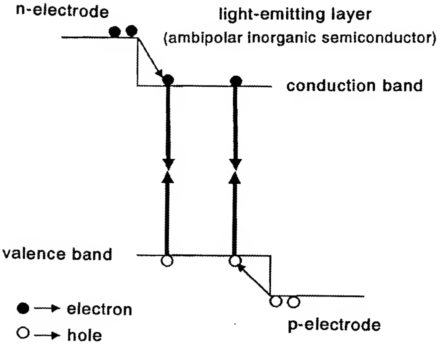
compares the conduction band edge energy to the work functions of the n-electrode and of the p-electrode. Only the differences between the band edge energies and the two work functions are important. All three are individually measured from a common reference energy, typically the Fermi energy although other reference energies may be used. In the differences, the reference energy cancels out and thus is unimportant and the differences are non-ambiguous despite the undefined reference energy. Typically, work functions are defined with respect to the vacuum level removed from the atom having an energy of 0 eV. Applicants are willing to amend claim 18 to define the conventional reference level, as is well known in the art. However, since only differences of energy levels are recited, the reference level can be any value without affecting the meaning of the claim.

The examiner has rejected claims 1-2, 4-9, and 11-18 under 35 U.S.C. 102(b) as being anticipated by Kawazu et al. (US patent 5,539,239). This rejection is traversed.

The present invention is based on ambipolar diffusion and recombination while Kawazu is based on quantum well. The following page includes presentation material provided by the assignee to illustrate the difference of the two. The circles represent holes.

The Present Invention

- The light-emitting layer is an ambipolar inorganic semiconductor including no dopant.
- Drift conduction in the light-emitting layer is obtained by carriers injected from the outside.
- Since the mobility of both carriers is in the same range (1/10~1), recombination emitting is obtained at the midpoint of the light-emitting layer.
- More than a band gap energy of the light-emitting layer is necessary for drive voltage.
- The thickness of the light-emitting layer is 10nm~10μm.



The characteristic of the present invention is that the light-emitting active area comprises an ambipolar semiconductor which is not doped with a dopant acting as either a donor or an acceptor. Therefore, only few holes and electrons initially exist in the light-emitting active area, about the number of thermal excitation carriers excited in room temperature though it is negligible few compared to the carriers derived from doped donor and acceptor to be mentioned below.

When an electric field is applied between the electrodes and current flows, the current comprises holes and electrons themselves which flow from the electrodes to the valence band and the conduction band. The conduction mechanism is the drift motion of each hole and electron in the valence band or the conduction band.

The number of carriers (holes and electrons) comprising the current is proportional to the product of the density and the mobility of the carriers injected from the electrodes.

There are quite a few n-type or p-type semiconductors purposefully undoped due to the crystal defects or dopants. For such semiconductors, it is possible to make them ambipolar semiconductors by doping other acceptors or donors so as to compensate the defects or dopants working as donors or acceptors.

Note in the above figure the lack of a barrier between the n-electrode and its associated work function and the conduction band and between the p-electrode and its associated work function and the valence band.

The following page is presentation material for the conventional quantum well structure to be contrast with the invention.

Quantum Well Structure

- Both carriers are injected to a light-emitting layer by tunneling the potential barrier.
- Both carriers are shut in the potential barrier.
  → Recombination emitting occurs because
  the distance between both carriers becomes close.
  (Since the carriers are shut in, there is no movement
  (in the direction of electric field) in the light-emitting layer)
- The drive voltage is more than shut-in level.
- The thickness of the light-emitting layer is thin in general, and no more than about 10nm.

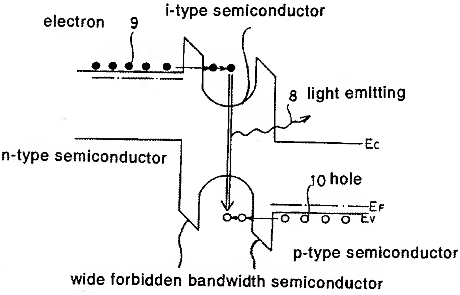


Fig. 1 of Japanese Patent Application Publication No. 4-120775

A quantum well structure is characterized by an light-emitting active area comprising two wide-bandgap semiconductor (insulator) layers acting as tunneling barriers or potential barriers of the quantum well and a narrow-bandgap semiconductor layer betweeem the barrier layers acting as a shut-in area (well) of the quantum well. In the light-emitting active area, at least one additional shut-in or confinement quantum level of electrons or holes is formed within the well and away from the respective valence and conduction bands of the well. Light emission occurs by the transition between the two additional confinement levels associated with conduction and valence bands respectively Therefore, electrons and holes do not transport in the light-emitting active area (i.e. shut-in state) between the electrodes. Thus, the quantum well structure has the "quantum shut-in" or confinement structure which is unrelated to the ambipolar semiconductor based on the drift "conduction".

When the electric field is applied and current flows, the current in the light-emitting active area of the quantum-well structure comprises the holes and the electrons themselves which are injected to the p-type semiconductor and the n-type semiconductor from the electrodes by the "tunneling" mechanism through the barriers. Therefore, the conduction mechanism is not the "drift motion" of each hole and electron, the valence band edge and the conduction band edge.

Accordingly, Kawazu's quantum well structure does not have the claimed ambipolarity. On the contrary, Kawazu's electrons and holes tunnel through his barrier layers.

The base claims 1, 13, and 18 have all been amended to require that the ambipolar light-emitting layer has a thickness of at least 100nm, as supported at [0015] of US 2006/0261350. In contrast, Kawazu's active layer, his quantum well, has a thickness of 10nm. No suggestion exists that Kawazu's active layer can be increased in thickness to 100nm and still function as his desired quantum well. On the contrary, it is well known in the field that quantum wells need to be have a thickness of less than about 10nm if they are demonstrate the confinement levels within the quantum well.

Also, base claims 1 and 18 have both been amended to require that the mobilities of the electrons and holes be within a factor of ten, thus providing the required ambipolarity.

Kawazu does not disclose relative mobilities and such relatively equal mobilities are not required for his quantum well confinement and optical transitions within the wells.

Claim 18 additionally recites the work functions of the electrodes. Kawazu does not describe work functions. The examiner states that the work function limitations of claim 18 are inherent in Kawazu since Applicant's discussion at [0111] of US 2006/0261350 is for the exact same structure. This statement is not supported by a complete comparison of the two documents. Applicants are discussing a barrier-free junction, which is generally much thicker than Kawazu's 10nm quantum well. Further, Kawazu requires a barrier, which is not present in [0111] of US 2006/0261350. Applicants' discussion at [0106]-[0107] is not restricted to Kaawzu's 10nm ZnSe active layer but is directed to non-barrier injection of both electrons and holes, a feature not discussed by Kawazu.

More specifically and with reference to the technical literature, Kawazu's electrodes do not exhibit the required work functions. Kawazu's electron injecting electrode is his n-type ZnSe cladding layer 5. It is common knowledge that the work function of n-type ZnSe is higher than the conduction band energy of undoped or intrinsic ZnSe. See Akio KUNIOKA and Kiichi KAMIMURA, "Kiso Handohtai Kohgaku (Basic Semiconductor Engineering)", ed. Asakura Shoten, 1996, pp. 25-29. Kawazu's hole injecting electrode is his p-type ZnSe cladding layer 3, which has a work function lower than the valence band energy of undoped (intrinsic) ZnSe. In contrast as defined in claim 18, the work function if the p-electrode must be higher than the valence band energy of the ambipolar semiconductor.

New dependent claims 19 and 21 again claim non-barrier junctions between the ambipolar semiconductor layer and its two junctions, as recited in the originally filed claims.

New dependent claims 20 and 22 recite compositions of Ga-doped ZnO and $CuFeS_2$ for the two electrodes, as supported at [0117] of US 2006/0261350.

The Commissioner is authorized to charge Deposit Account 50-0636 any required fee including extension fees and extra-claim fees.

In view of the above amendments and remarks, reconsideration and allowance of all claims are respectfully requested. If the Examiner believes that a telephone interview would be helpful, he is invited to contact the undersigned attorney at the listed telephone number, which is on California time.

Respectfully submitted,

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